NASA Science Mission Directorate - Applied Sciences Program

Water Management – Fiscal Year 2005 Annual Report [*]

SUMMARY

In FY05 the Water Management program element largely focused on extending MODIS and Land Data Assimilation System / Land Information Systems (LDAS/LIS) products to four management decision support systems: BASINS–Better Assessment Science Integrating Point and Nonpoint Sources (U.S. EPA), RiverWare and AWARDS–Agricultural Water Resources Decision Support (Bureau of Reclamation–BoR), and Eta (NOAA).

The team accomplished a significant milestone with a benchmark report on the use of the North American Land Data Assimilation System (NLDAS) land surface states to improve the NOAA Eta model for weather forecasting. In addition, the team accomplished significant progress towards use of NASA satellite products by BoR and EPA through LIS products and accompanying land surface models (LSMs) in BASINS, RiverWare, and the AWARDS Evapotranspiration (ET)-Toolbox.

MAJOR ACCOMPLISHMENTS

Benchmark Report for NLDAS products in NOAA National Centers for Environmental Prediction (NCEP) Eta Mesoscale Forecasting

The project team performed benchmarking of NLDAS land surface states and MODIS snow cover data through comparisons of a series of retrospective NOAA Eta weather model simulations. (NASA, NOAA, and a consortium of universities developed NLDAS, and its input involves products from MODIS and other satellites.) The team used LIS to generate initial states for 20 control simulations and 60 experimental simulations. The use of NLDAS initial conditions, along with use of MODIS snow cover, greatly improved surface forecasts of relative humidity and temperature. When MODIS snow cover was assimilated into NLDAS initial conditions, the Eastern U.S. bias in 2-meter temperature forecasts from baseline Eta model simulations improved by 21% versus standard NCEP simulations, and they improved by 16% over the western half of the continental United States (CONUS). Similarly, the 2-meter relative humidity forecasts improved by 78% over the eastern CONUS and by 15% over the western CONUS versus the NCEP baseline run in these same simulations. Building on the promising approach with NLDAS uncoupled initializations, the project will pursue further development before a potential consideration for operational implementation within NOAA NCEP. The Water Management program expects NOAA to eventually adopt some of the techniques and data sets utilized in this project.

BoR RiverWare & AWARDS ET Toolbox

In collaboration with BoR, this project focused on evaluating and benchmarking NASA Earth science products for RiverWare and AWARDS ET-Toolbox decision tools; LIS water availability products and satellite MODIS snow and land cover products were of primary interest for inclusion in BoR's tools. The team also worked on integrating Earth science products in an observation-based modeling system addressing BoR regional office needs. The team evaluated retrospective studies and near real-time simulations to determine how NASA Earth science products enhanced monitoring and forecasting of water supply and extreme events. BoR team members created computer programs to incorporate and evaluate the first set of 1/8 degree NLDAS and 1-km LIS model runs, helped evaluate forcing fields used

[*] The FY05-09 Water Management Program Element Plan is available through: *http://aiwg.gsfc.nasa.gov/dss.html*

in NLDAS and LIS, and helped validate the snow water equivalent and soil temperature fields from these runs. Initial results have shown BoR decision tool enhancements through special applications of LIS ET, LIS soil moisture, LIS precipitation, MODIS-derived snowpack, and MODIS-derived land cover information.

In FY05, the team successfully developed and integrated the latest MODIS version 4 (MODIS.v4) land products for use in the LSMs in LIS, including land cover classification (MOD12), the land-water mask (MOD12), leaf area index (MOD15), land surface temperature (MOD11), and snow cover (MOD10). The project found that MODIS snow cover could identify snow in grid pixels correctly when no cloud cover was detected, which has been deemed suitable for use in several of the LSMs.

The team also used MODIS surface temperature data to update the ET transfer coefficients used by BoR in support of the AWARDS ET-Toolbox (the current transfer coefficients were out of date). This work also resulted in quality control and correction of the MODIS Land Surface Temperature Product. The project team applied data-merging techniques to LIS products in order to appropriately align different satellite datasets and parameters for use in land surface models, enabling the team to remove existing artifacts in datasets and improve use of LSMs by decision tools. The project team includes NASA, BoR, Desert Research Institute (DRI), University of Nevada, and University of Idaho, and the project study areas included the Truckee-Carson Rivers, Columbia River, and the Middle Rio Grande River Basins.

EPA BASINS

The project team evaluated NASA LIS water availability products (precipitation and ET) and MODIS Land Cover and Vegetation Index products to improve water quality modeling for BASINS. Specifically, the project focused on Hydrological Simulation Program-FORTRAN (HSPF), which is a continuous watershed model that produces a streamflow hydrograph at specific points in a drainage basin. Improvements to the predictive capability of HSPF produce more accurate streamflow in BASINS as well as identification of specific water quality parameters, such as pollutant concentrations.

The project expects that spatially-distributed precipitation product derived from LIS should produce improved forcing when compared to the gauge-only approach currently used by EPA. In addition, the project team has used LIS ET products to provide a spatially- distributed estimate that is superior to the current ET models used in HSPF. Both Landsat and MODIS data were effectively shown to model the export of nitrogen deposition in the watershed from the intensity of defoliation via environmental disturbances.

In FY05, project team members demonstrated that LIS ET provided significantly improved flow estimates for BASINS. The team also demonstrated that use of MODIS Land Cover and Vegetation Index products and Landsat data led to successful monitoring of water quality nutrients and sediments from ecosystem disturbances, such as from logging and gypsy moth defoliation.

In FY06, the project team will customize NASA products for improving BASINS water quality, and the team expects to complete an evaluation report and a benchmark report for BASINS. The project team includes NASA, EPA, Hunter College, and the University of Maryland-Center for Environmental Studies (UMCES); Mississippi State University supports the non-point source pollution work.

ADDITIONAL ACCOMPLISHMENTS

NASA Representation in UNESCO-WMO Hydrology for the Environment, Life, and Policy (HELP)
NASA (through the Applied Sciences Program, NASA-Goddard Terrestrial Hydrology Program, and the University of Maryland Baltimore County-Goddard Earth Science and Technology Center) coordinated the North America region of the Hydrology for the Environment, Life, and Policy Program (HELP). The United Nations Educational, Scientific, and Cultural Organization's (UNESCO's) and the World Meteorological Organization (WMO) established HELP in 1999 to bring water managers, decision makers, stakeholders, scientists, and academicians together to determine needs and find solutions to water management issues through a "bottom-up" approach. NASA support has been instrumental to HELP through numerous meetings and teleconferences.

In FY05, the Water Management team worked on the "Maghreb" interagency effort (countries of Tunisia, Algeria and Morocco) to support possible water management activities through a State Department request. NASA helped coordinate an interagency study involving USGS, USDA, NOAA, and State Department to identify water management issues for State Department's Science and Technology initiative. NASA led a delegation of water resources specialists to evaluate specific water resources problems in the Maghreb region, including identification and prioritization of each country's water resource and water management needs.

SOLICITATIONS

Decisions CAN
The Water Management Program received 36 Step-1 proposals in the Decisions CAN and encouraged 25 to submit full proposals. In Step-2, the Water Management program received 22 full proposals. Following the panel reviews and internal assessment for programmatic balance, the Applied Sciences Program selected a Water Management proposal (in conjunction with the Energy Management program):

> Improving Water Resources Management in the Western U.S. through Use of Remote Sensing Data and Seasonal Climate Forecasts
> *PI: Dennis Lettenmaier, University of Washington-Seattle*

The Applied Sciences Program selected the following proposals for a single, combined project serving the Water Management and Disaster Management program elements:

> Use of NASA Remote Sensing Datasets in NOAA National Weather Service River Forecast Centers' Hydrologic Modeling
> *PI: Ashutosh Limaye, Universities Space Research Association*
>
> Improving NOAA/NWS River Forecast Center Decision Support with NASA Satellite and Land Information System Products
> *PI: Pedro Restrepo, NOAA*

The Program also selected the following proposals for a single, combined project serving the Water Management and Disaster Management program elements:

> National Drought Monitoring System for Drought Early Warning Using Hydrologic and Ecologic Observations from NASA Satellite Data
> *PI: Son V. Nghiem, NASA–Jet Propulsion Laboratory*
>
> Enhancement of the U.S. Drought Monitor by Integrating NASA Earth Science Data
> *PI: James Verdin, USGS EROS Data Center*

The Applied Sciences Program later selected additional proposals for one-year awards from a Congressionally-directed augmentation, including one project for the Water Management program portfolio (in conjunction with the Disaster Management program):

> Flood Inundation Enhancement for NOAA's Advanced Hydrologic Prediction Service
> *PI: G. Robert Brakenridge, Dartmouth College*

PUBLICATIONS AND CONFERENCE/WORKSHOP PRESENTATIONS AND POSTERS (SELECTED)

Arsenault, K., P. Houser, S. Hunter, D. Frevert, S. Meyer, and D. Matthews, "The use of land data assimilated products to improve flood and drought risk analysis and forecasting in the Columbia River Basin," poster presented at the *85th AMS Annual Meeting*, January 2005, San Diego, CA.

Arsenault, K., A. Pinheiro, R. Stodt, D. Matthews, and P. Houser, 2005. "A comparison of LDAS Land surface model evapotranspiration estimates using satellite-derived products," poster presented at the *USBR-Alliance University Evapotranspiration Workshop*, February 2005, Denver, CO.

Toll, D., K. Arsenault, C. Peters-Lidard, P. Houser, S. Kumar, E. Engman, J. Nigro, and J. Triggs, "NASA LIS Water Availability to Support Reclamation ET Estimation," *US Bureau of Reclamation/ USDA/USGS Evapotranspiration Workshop*, March 2005, Fort Collins, CO. Technical Presentation and Technical Paper.

Toll, D., X. Zhan, and C. Peters-Lidard, "NASA Soil Moisture Observations and Modeling," *NASA-USDA FAS Project Review*, October 2004, College Park, MD, E. Sheffner Review Coordinator, Technical Presentation.

Toll, D., J. Triggs, J. Nigro, K. Arsenault, E. Engman and A. Pinheiro, 2005. "Improving Water Management Decision Support Systems Using NASA Data Products," *NASA-USDA 2nd Applications Workshop*, April 2005, New Orleans, Poster Presentation.

Toll, D., R. Eckman, and S. Habib, 2005. "NASA Research and Applications for Renewable Hydroelectric Energy Use," *Renewable Energy Modeling Series-Modeling Hydroelectric Energy Use*, NREL Workshop, May 2005, Washington, DC.

Triggs, J., HELP session coordinator, 2005. "Managing Watersheds for Human and Natural Impacts: Engineering, Ecological, and Economic Challenges," *ASCE-EWRI Watershed Management 2005 Conference*, July 2005, Williamsburg, VA.

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